# ACPI-C a, H Acc ac, M c ce S e Té e a e M

The ADM1023 is a 2-channel digital thermometer and under/overtemperature alarm for use in personal computers and other systems requiring thermal monitoring and management. Optimized for the Pentium III, the higher accuracy allows systems designers to

performance. The device can measure the temperature of a microprocessor using a diode-connected PNP transistor, which may be provided on-chip with the Pentium III or similar processors; or it can be a low-cost, discrete NPN/PNP device such as the 2N3904/2N3906. A novel measurement technique cancels out the absolute value of the transistor's base emitter voltage so that no calibration is required. The second measurement channel measures the output of an on-chip temperature sensor to monitor the temperature of the device and its environment.

The ADM1023 communicates over a 2-wire serial interface compatible with SMBus standards. Under/overtemperature limits can be programmed into the device over the serial bus, and an ALERT output signals when the on-chip or remote temperature is out of range. This output can be used as an interrupt or as an SMBus ALERT.

#### Features

Next Generation Upgrade of ADM1021 On-Chip and Remote Temperature Sensing Offset Registers for System Calibration 1 C Accuracy and Resolution on Local Channel 0.125 C Resolution/1 C Accuracy on Remote Channel Programmable Over/Undertemperature Limits Programmable Conversion Rate Supports System Management Bus (SMBus) ALERT 2-Wire SMBus Serial Interface





Table 4. ELECTRICAL CHAF	<b>RACTERISTICS</b> ( $T_A = T_{MIN}$ to	$T_{MAX}$ , $V_{DD} = 3.0$ V to 3.6 V,	unless otherwise noted. (I	Note 1)
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Parameter	Test Conditions/Comments	Min	Тур	Max	Unit
SMBus Interface (See Figure 2)					
Logic Input High Voltage, V <sub>IH</sub> STBY, SCLK, SDATA	V <sub>DD</sub> = 3.0 V to 5.5 V	2.2			

### **TYPICAL PERFORMANCE CHARACTERISTICS**



Figure 9. Temperature Error vs. Differential-mode Noise Frequency Figure 10. Operating Supply Current vs. Conversion Rate,  $V_{DD}$  = 5.0 V and 3.3 V

Figure 11. Standby Supply Current vs. Supply Voltage Figure 12. Response to Thermal Shock

#### **Theory of Operation**

#### **Functional Description**

The ADM1023 contains a two-channel analog-to-digital converter (ADC) with special input-signal conditioning to enable operation with remote and on-chip diode temperature sensors. When the ADM1023 is operating normally, the ADC operates in a free-running mode. The analog input multiplexer alternately selects either the on-chip temperature sensor to measure its local temperature or the remote temperature sensor. These signals are digitized by the ADC, and the results are stored in the local and remote temperature value registers. Only the eight most significant bits (MSBs) of the local temperature value are stored as an 8-bit binary word. The remote temperature value is stored as an 11-bit binary word in two registers. The eight MSBs are stored in the remote temperature value high byte register at Address 0x01. The three least significant bits (LSBs) are stored, left justified, in the remote temperature value low byte register at Address 0x10.

Error sources such as PCB track resistance and clock noise can introduce offset errors into measurements on the remote channel. To achieve the specified accuracy on this channel, these offsets must be removed, and two offset registers are provided for this purpose at Address 0x11 and Address 0x12.

An offset value may automatically be added to or subtracted from the measurement by writing an 11-bit, twos complement value to Register 0x11 (high byte) and Register 0x12 (low byte, left-justified).

The offset registers default to 0 at powerup and have no effect if nothing is written to them.

The measurement results are compared with local and remote, high and low temperature limits, stored in six

on-chip limit registers. As with the measured value, the local temperature limits are stored as 8-bit values and the remote temperature limits as 11-bit values. Out-of-limit comparisons generate flags that are stored in the status register, and one or more out-of-limit results cause the ALERT output to pull low.

Registers can be programmed, and the device controlled and configured, via the serial system management bus (SMBus). The contents of any register can also be read back via the SMBus.

Control and configuration functions consist of:

Switching the Device between Normal Operation and Standby Mode

Masking or Enabling the ALERT Output

Selecting the Conversion Rate

On initial powerup, the remote and local temperature values default to –128 C. The device normally powers up converting, making a measure of local and remote temperature. These values are then stored before making a comparison with the stored limits. However, if the part is powered up in standby mode (STBY pin pulled low), no new values are written to the register before a comparison is made. As a result, both RLOW and LLOW are tripped in the status register, thus generating an ALERT output. This may

#### Temperature Data Format

One LSB of the ADC corresponds to 0.125 C, so the ADM1023 can measure from 0 C to 127.875 C. The temperature data format and extended temperature resolution are shown in Table 5 and Table 6.

# Table 5. TEMPERATURE DATA FORMAT (LOCAL AND REMOTE TEMPERATURE HIGH BYTE)

Temperature (°C) (Note 1)	Digital Output
0	0 000 0000
1	0 000 0001
10	0 000 1010
25	0 001 1001
50	0 011 0010
75	0 100 1011
100	0 110 0100
125	0 111 1101
127	0 111 1111

1. The ADM1023 differs from the ADM1021 in that the temperature resolution of the remote channel is improved from 1 C to 0.125 C, but it cannot measure temperatures below 0 C. If negative temperature measurement is required, the ADM1021 should be used.

The results of the local and remote temperature measurements are stored in the local and remote temperature

#### Table 7. LIST OF ADM1023 REGISTERS

Read Address (Hex)	Write Address (Hex)	Name	Power-on Default
Not Applicable	Not Applicable	Address Pointer	Undefined
00	Not Applicable	Local Temperature Value	1000 0000 (0x80) (-128 C)
01	Not Applicable	Remote Temperature Value High Byte	1000 0000 (0x80) (-128 C)
02	Not Applicable	Status	Undefined
03	09	Configuration	0000 0000 (0x00)
04	0A	Conversion Rate	0000 0010 (0x02)
05	0B	Local Temperature High Limit	0111 1111 (0x7F) (+127 C)
06	0C	Local Temperature Low Limit	1100 1001 (0xC9) (-55 C)
07	0D	Remote Temperature High Limit High Byte	0111 1111 (0x7F) (+127 C)
08	0E	Remote Temperature Low Limit High Byte	1100 1001 (0xC9) (-55 C)
Not Applicable	0F (Note 1)	One-shot	

#### Table 9. STATUS REGISTER BIT ASSIGNMENTS

 Bit
 Name
 Function

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 7

ADD0	ADD1	Device Address
0	0	0011 000
0	NC	0011 001
0	1	0011 010
NC	0	0101 001
NC	NC	0101 010
NC	1	0101 011
1	0	1001 100
1	NC	1001 101
1	1	1001 110

#### Table 12. DEVICE ADDRESSES (Note 1)

1. ADD0 and ADD1 are sampled at powerup only.

The serial bus protocol operates as follows:

 The master initiates data transfer by establishing a start condition, defined as a high-to-low transition on the serial data line, SDATA, while the serial clock line, SCLK, remains high. This indicates that an address/data stream will follow. All slave peripherals connected to the serial bus respond to the start condition and shift in the next 8 bits. These bits consist of a 7-bit address (MSB first) plus an R/W bit, which determines the direction of the data transfer, that is, whether data is written to, or read from, the slave device.

The peripheral whose address corresponds to the transmitted address responds by pulling the data

line low during the low period before the ninth clock pulse, known as the Acknowledge bit. All other devices on the bus remain idle while the selected device waits for data to be read from or written to it. If the R/W bit is 0, the master writes to the slave device. If the R/W bit is 1, the master reads from the slave device.

- 2. Data is sent over the serial bus in sequences of nine clock pulses, 8 bits of data followed by an A cknowledge bit from the slave device. Transitions on the data line must occur during the low period of the clock signal and remain stable during the high period, because a low-to-high transition when the clock is high may be interpreted as a stop signal. The number of data bytes that can be transmitted over the serial bus in a single read or write operation is limited only by what the master and slave devices can handle.
- 3. When all data bytes have been read or written, stop conditions are established. In write mode, the master pulls the data line high during the 10th clock pulse to assert a stop condition. In read mode, the master device overrides the Acknowledge bit by pulling the data line high during the low period before the ninth clock pulse. This is known as No Acknowledge. The master then takes the data line low during the low period before the 10th clock pulse, then high during the 10th clock pulse to assert a stop condition.



Figure 15. Writing a Register Address to the Address Pointer Register, then Writing Data to the Selected Register



Figure 17. Reading Data from a Previously Selected Register

address. The address of the device is now known, and it can be interrogated in the usual way.

- 4. If more than one device's ALERT output is low, the one with the lowest device address has priority, in accordance with normal SMBus arbitration.
- 5. Once the ADM 1023 has responded to the ARA, it

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